U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-270 064

Cotile Reservoir, Rapides Parish, Louisiana

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Mar 77

PB 270 064

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

REPORT

ON

COTILE RESERVOIR

RAPIDES PARISH

LOUISIANA

EPA REGION VI

WORKING PAPER NO. 537

WITH THE COOPERATION OF THE

LOUISIANA WILD LIFE AND FISHERIES COMMISSION

AND THE

LOUISIANA NATIONAL GUARD

MARCH, 1977

TECHNICAL REPORT DATA

1 REPORT NO

2

3 RECIPIENT'S ACCESSION NO

4 TITLE AND SUBTITLE
Report on Cottle Reservoir, Rapides Parish, Louisiana

5 REPORT DATE
Prepared March 1977

6 PERFORMING ORGANIZATION CODE

7 AUTHOR(S)
Anonymous (National Eutrophication Survey Staff)

8 PERFORMING ORGANIZATION REPORT NO
Working Paper No. 537

9 PERFORMING ORGANIZATION NAME AND ADDRESS
National Eutrophication Survey
U.S. Environmental Protection Agency
P.O. Box 15027
Las Vegas, NV 89114

10 PROGRAM ELEMENT NO

11 CONTRACT/GRANT NO

12 SPONSORING AGENCY NAME AND ADDRESS
Office of Research and Development
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, DC 20460

13 TYPE OF REPORT AND PERIOD COVERED
Final - 1974

14 SPONSORING AGENCY CODE

15 SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16 ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17 KEY WORDS AND DOCUMENT ANALYSIS

a DESCRIPTORS	b IDENTIFIERS/OPEN ENDED TERMS	c COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18 DISTRIBUTION STATEMENT
Release unlimited

19 SECURITY CLASS (This Report)

20 SECURITY CLASS (This page)

21 NO. OF PAGES
17

22 PRICE
PC A02 / MF A01

EPA Form 2220-1 (9-73)

1.8

REPORT ON COTILE RESERVOIR

RAPIDES PARISH, LOUISIANA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 517

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

March 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Louisiana Wild Life and Fisheries Commission, Division of Water Pollution Control for professional involvement, to the Louisiana National Guard for conducting the tributary sampling phase of the Survey, and to those Louisiana wastewater treatment plant operators who provided effluent samples and flow data.

Robert A. Lafleur, Chief; J. Dale Givens, Assistant Chief; Lewis R. Still, Biologist; Louis Johnson, Biologist; Lee Caubarreaux, Biologist; Darrell Reed, Engineer; Dempsey Alford, Biologist; and Elwood Goodwin, Water Quality Control Technician, all of the Louisiana Wild Life and Fisheries Commission, Division of Water Pollution Control reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

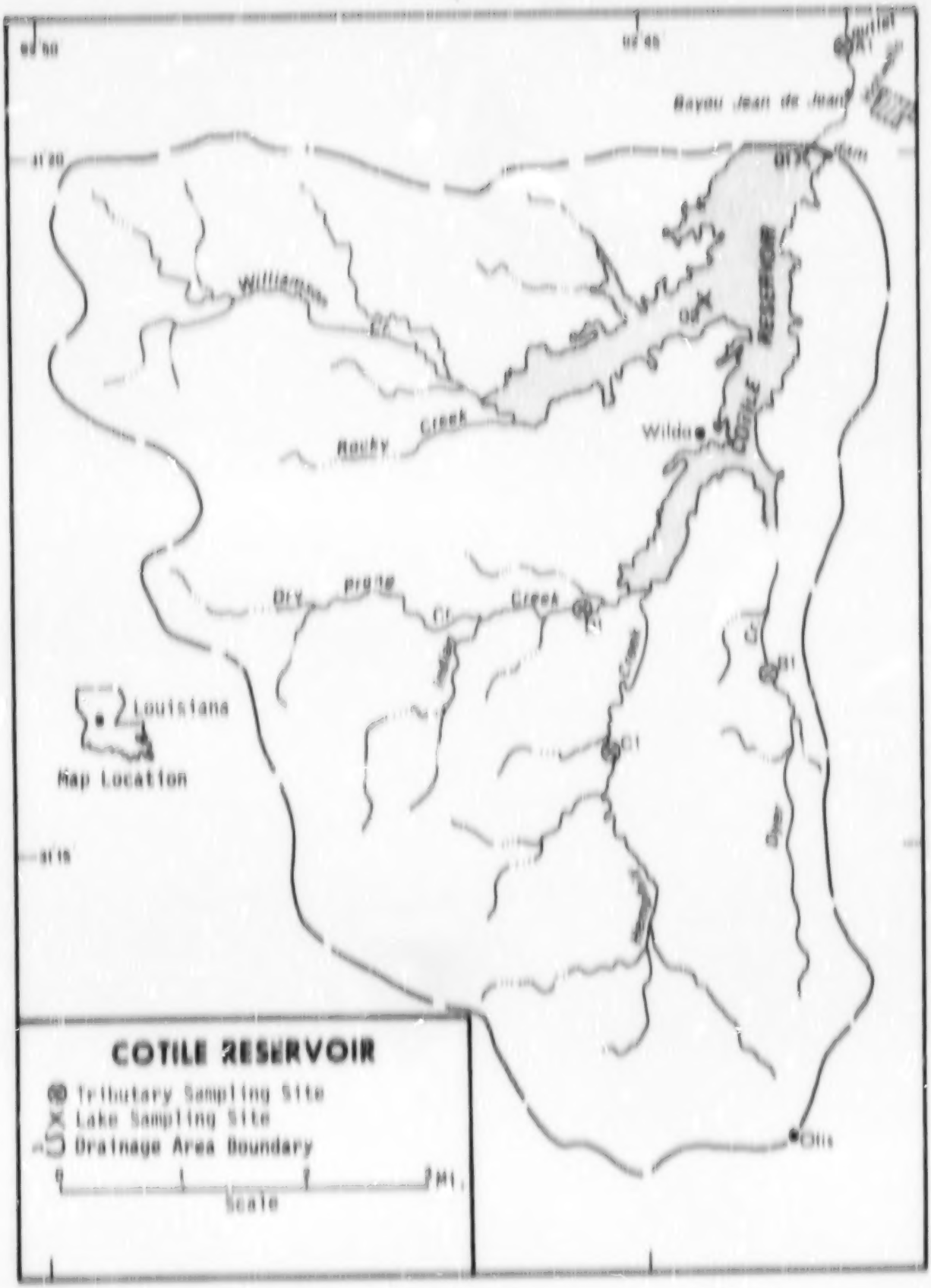
Major General O'Neil Daigle, Jr., the Adjutant General of Louisiana, and Project Officer Colonel Lawrence P. Dupre, who directed the volunteer efforts of the Louisiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF LOUISIANA

LAKE NAME	COUNTY
Anacoco Lake	Vernon
Lake Bistineau	Bienville, Webster
Black Bayou	Caddo
Black Lake	Natchitoches and Red River
Bruin Lake	Tensas
Bundick Lake	Beauregard
Caddo Lake	Caddo (Menon and Harrison in Texas)
Cocodrie Lake	Concordia
Cocodrie Lake (Lower)	Rapides
Concordia Lake	Concordia
Cottle Lake	Rapides
Cross Lake	Caddo
D'Arbonne Lake	Union
False River Lake	Pointe Coupee
Indian Creek Reservoir	Rapides
Saline Lake	LaSalle
Turkey Creek Lake	Franklin
Lake Vernon	Vernon
Lake Verret	Assumption


Bayou Jean de Jean
Williams
Rocky Creek
Wilda
Dry Prong Creek
Louisiana
Map Location
Olla
COTILE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale
Mi.

REPORT ON COTILE RESERVOIR, LOUISIANA

STORET NO. 2208

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate Cotile Reservoir is meso-eutrophic. The lake is characterized by moderate Secchi disc transparency (mean 146 cm), and low potential for primary production as measured by algal assay control yield. Chlorophyll a values ranged from 6.3 µg/l in the fall to 18.5 µg/l in the spring with a mean of 12.6 µg/l. Of the 19 Louisiana lakes sampled in 1974, 15 had higher median total phosphorus, 9 had greater median inorganic nitrogen, and 11 had higher median orthophosphorus than Cotile Lake.

Survey limnologists reported no problem conditions on this lake.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Cotile Reservoir was limited by available phosphorus levels. Spikes with phosphorus or nitrogen and phosphorus simultaneously resulted in increases in assay yield. Additions of nitrogen alone did not stimulate a growth response. The ratios of available nitrogen to orthophosphorus (N/P) in sampled waters, however, suggest nitrogen limitation on all sampling occasions.

*See Appendix I.

C. Nutrient Controllability:

1. Point sources -

There were no known point sources impacting Cottle Reservoir. However, loading calculations based upon available nutrient concentrations and flow data yield an apparent net export of both phosphorus and nitrogen from the lake. This export could be due to 1) undetected discharges reaching the lake from unknown industrial or municipal sources, 2) loading ratios for the Cottle Reservoir outlet (Cottle Creek) which are inflated by unknown discharges which enter the stream at some point between the lake outlet and the A-1 sampling site, or 3) failure to sample Williamson Creek, and thus underestimating that tributary's ungaged loading to the lake. Additional sampling and an evaluation of current land use and lake shore construction are required before a nutrient budget for the lake can be determined.

2. Nonpoint sources -

Nonpoint sources contributed the entire known phosphorus load to Cottle Lake. Major tributaries contributed 44.1% of the total load, and minor tributaries (ungaged) were estimated to have contributed 52.0%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the State of Louisiana. Maximum depth was obtained from contour maps provided by the Louisiana Stream Control Commission. Tributary flow data were provided by the Louisiana District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 7.29 km^2.
2. Mean depth: 4.3 meters.
3. Maximum depth: 7.6 meters.
4. Volume: 30,897 x 10^6 m^3.
5. Mean hydraulic retention time: 206 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage Area (km^2)	Mean Flow (m^3/sec)
B-1 Dyer Creek	8.7	0.11
C-1 Hemphill Creek	22.1	0.32
D-1 Indian Creek	13.3	0.22
Minor tributaries and immediate drainage -	53.4	1.00
Totals	97.5	1.70
2. Outlet - A-1 Cottle Creek	104.6	1.74

C. Precipitation:

1. Year of sampling: 141.0 cm.
2. Mean annual: 137.3 cm.

III. LAKE WATER QUALITY SUMMARY

Cottle Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 15.0-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 4.6 meters at Station 01 and 4.6 meters at Station 02. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

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B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/20/74	1. Melosira	3,220
	2. Cryptomonas	867
	3. Flagellates	794
	4. Merismopedia	700
	5. Ankistrodesmus	607
	Other genera	3,060
	Total	9,208
05/30/74	1. Dactylococcopsis	634
	2. Cyclotella	493
	3. Cryptomonas	423
	4. Asterionella	352
	5. Microcystis	352
	Other genera	1,760
	Total	4,014
11/12/74	1. Merismopedia	1,300
	2. Flagellates	917
	3. Microcystis	917
	4. Kirchneriella	841
	5. Aphanocapsa	459
	Other genera	1,991
	Total	6,425

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/20/74	01	10.5
	02	13.9
05/30/74	01	14.0
	02	12.8
11/12/74	01	10.4
	02	6.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked - 03/23/74

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.015	0.083	0.3
0.05 P	0.065	0.083	3.0
0.05 P + 1.0 N	0.065	1.083	14.6
1.00 N	0.015	1.083	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary productivity was low in Cattle Reservoir during the spring sampling season. Increased growth of the test alga in response to an addition of orthophosphorus indicates the lake was phosphorus limited when sampled. Spikes with nitrogen and phosphorus simultaneously resulted in maximum yield.

It should be noted that significant chemical changes took place in Louisiana lake samples between collection and algal assay. The assay data should be considered in this context and until such differences are resolved, used with caution for any prediction of actual lake conditions. Such chemical changes are likely to alter the control yield as well as modifying the N/P ratio. The autumn algal assay results have not been included in this report because these substantial changes in nutrient levels have removed their information value.

The N/P ratios in the field samples were 9/1 in the spring, 13/1 in the summer, and 5/1 in the fall, suggesting nitrogen limitation.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Louisiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February, March, and April when two samples were collected. Sampling was begun in June 1974, and was completed in May 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Louisiana District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/yr$, in Dyer Creek, Hemphill Creek, and Indian Creek at Stations B-1, C-1, and D-1, and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Dyer Creek	255	7.5
C-1 Hemphill Creek	820	24.2
D-1 Indian Creek	420	12.4
b. Minor tributaries and immediate drainage (nonpoint load) -	1,760	52.0
c. Known municipal STP's - None		
d. Septic tanks* -	5	0.2
e. Known industrial - None		
f. Direct precipitation** -	125	3.7
Totals	3,385	100.0
2. Output - A-1 Cottle Creek	4,150	
3. Net annual P export*** -	765	

*Estimate based on 10 lakeside residences.
**Estimated (see NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Dyer Creek	1,690	5.2
C-1 Hemphill Creek	6,645	20.4
D-1 Indian Creek	3,175	9.8
b. Minor tributaries and immediate drainage (nonpoint load) -	13,085	40.2
c. Known municipal STP's - None		
d. Septic tanks* -	105	0.3
e. Known industrial - None		
f. Direct precipitation** -	7,825	24.1
Totals	32,525	100.0
2. Output - A-1 Cottle Creek	45,175	
3. Net annual N export*** -	12,650	

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Dyer Creek	29	194
Hemphill Creek	37	301
Indian Creek	32	239

*Estimate based on 10 lakeside residences.
**Estimated (see NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

E. Yearly loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Cottle Reservoir	0.47
Vollenweider's "eutrophic" loading	0.15
Vollenweider's "oligotrophic" loading	0.08

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

APPENDIX C
PHYSICAL AND CHEMICAL DATA

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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* [illegible]
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APPENDIX E

PARAMETRIC RANGINGS OF LAKES
SAMPLED BY NES IN 1974

STATE OF LOUISIANA

LAKE DATA TY AK (KEY) IN ARKANSAS

LAKE CODE	LAKE NAME	[illegible] TOTAL *	[illegible] INDEX *	[illegible] AGE SEC	[illegible] CALCIUM	[illegible]	[illegible] SEDIMENT *
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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